The IACOB spectroscopic database of Northern Galactic OB stars

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Abstract: We present the IACOB spectroscopic database, an homogeneous set of high quality, high resolution spectra of Galactic O- and B-type stars obtained with the FIES spectrograph attached to the Nordic Optical Telescope. We also present some results from ongoing projects using the IACOB database.

1 Introduction

In an epoch in which we count on a new powerful generation of stellar atmosphere codes that include most of the relevant physics for the modelling of massive OB stars, with (clusters of) high efficiency computers allowing the computation of large grids of stellar models in more than reasonable computational times, and with the possibility to obtain good quality, medium resolution spectra of hundreds O and B-type stars in clusters outside the Milky way in just one snapshot (see e.g. the *FLAMES I & II Surveys of Massive Stars*, Evans et al. 2008, 2010), the compilation of medium and high-resolution spectroscopic databases of OB stars in our Galaxy is becoming more and more important. With this idea in mind, two years ago we began to compile the IACOB spectroscopic database, aiming at constructing the largest database of multiepoch, high resolution, high signal-to-noise ratio (S/N) spectra of Galactic Northern OB-type stars. The IACOB database perfectly complements the efforts also devoted in the last years by the GOSSS (P.I. Maíz-Apellaniz; see also Sota et al., these proceedings) and the OWN (P.I's Barbá & Gamen, leading a multi-epoch, high-resolution spectroscopic survey of Galactic O and WR stars in the Southern hemisphere; see Barbá et al. 2010) teams.

1.1 Characteristics of the IACOB database and present status

We are using the FIES spectrograph[1] at the 2.56 m Nordic Optical Telescope (NOT) in the Roque de los Muchachos observatory (La Palma, Spain) to compile spectra for the IACOB database. A summary of the instrumental configuration and observing dates (before Sept. 2010) is presented in Table 1. Spectra of $\sim$100 stars with spectral types earlier than B2 and luminosity classes ranging from I (supergiants) to V (dwarfs) have been already compiled. The O-type targets were selected

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[1] Detailed information about the NOT and FIES can be found in http://www.not.iac.es

Table 1: General characteristics of the IACOB v1.0 spectroscopic database.

Instrumental configuration		Observing run & Dates	
Telesc.: NOT 2.56 m	Spect. range: 3800 - 7000 Å	08 A-D: 2008/11/05-08,	10 D: 2010/06/22
Instr.: FIES	Res. power: 46000	09 A-D: 2009/11/09-12,	10 E: 2010/07/15
Mode: med-res	Sampling: 0.03 Å/pix	10 A-C: 2010/06/05-07,	10 F: 2010/08/07
Spectral types: O4-B2 (I-V)		# stars: 105	# spectra: 720

among those stars with V ≤ 8 included in the GOS catalogue (GOSC, Maíz-Apellániz et al. 2004). The main part of the B-type stars sample correspond to the works presented in Simón-Díaz (2010) and Simón-Díaz et al. (2010). The final spectra usually have S/N ≥ 200.

In Fig. 1 we present some examples of spectra in the IACOB database and studies that can be performed with them.
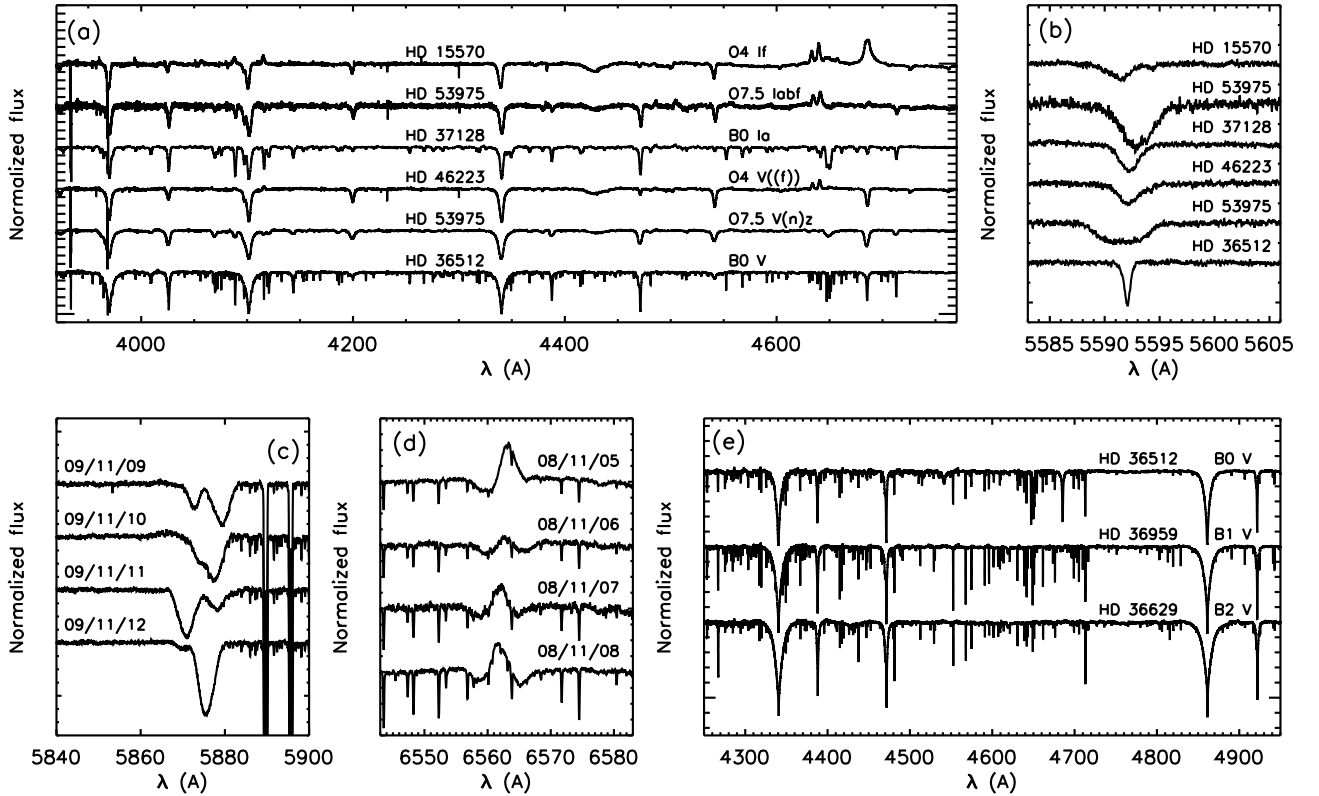

Figure 1: Illustrative examples of studies that can be performed using spectra from the IACOB database. (a) Spectra of a selected sample of MK standar stars centered in the spectral region usually considered for the spectral classifications, (b) same stars in the region where the O III 5592 line is located; this line in the red part of the spectrum can be used to characterize the rotational and macroturbulent broadening in O-type stars, where the Si III 4552 line is no longer available. (c) HD 1337, a double spectroscopic binary, observed in four consequetive nights, (d) HD 37128, a B0 Ia star in which has been detected strong variability in the Hα line (this star is one of the selected targets for the investigation of the macroturbulent broadening-pulsation connection in B supergiants, (e) Three narrow lined B-type stars from the Ori OB1 association, used in the reinvestigation of the chemical composition of young stars in the Orion star forming region.

2 Some ongoing projects using the IACOB spectroscopic database

2.1 Rotational velocities and macroturbulent broadening in OB stars

We used the FT method (viz Gray 1976; see also Simón-Díaz & Herrero 2007, for a recent application to OB stars) to disentangle the rotational and macroturbulent broadening and estimate their values in the whole sample of stars (see Fig. 2). This analysis has allowed us to confirm for the first time in a systematic way the presence of an important non-rotational broadening in O-stars of all luminosity classes. If this effect is not taken into account, it can significantly affect our v sini measurements. The origin of this broadening is still not clear and presently under study (see below).
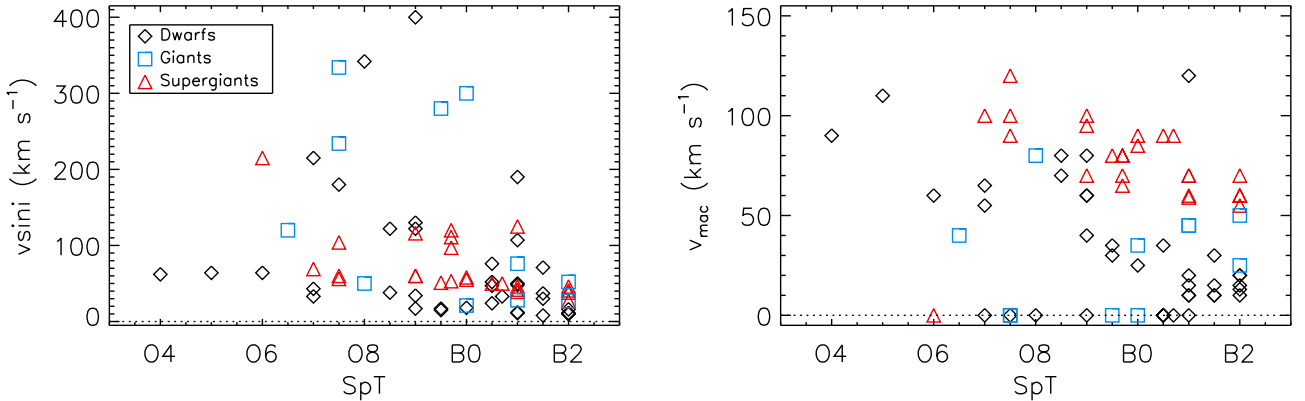

Figure 2: Rotational and macroturbulent velocities measured in the IACOB spectra. Double lined spectra were discarded. Not only the B Supergiants, but also the O-type stars show an important macroturbulent broadening. The increasing trend of v_{mac} with SpT, previously found for B Supergiants (e.g. Fraser et al. 2010, and references therein), is continued in the O star domain. Note also the separation between dwarfs, giants and supergiants.

2.2 Is macroturbulent broadening in OB stars related to pulsations?

Part of the IACOB database consists of spectroscopic time series of 13 early-B Sgs (+ 2 early-B dwarfs and 2 late-B Sgs). These observations were obtained to investigate the origin of the macroturbulent broadening in OB stars and its possible relation to spectroscopic variability phenomena and stellar pulsations. First results show a tight correlation between the size of macroturbulent broadening and the line-profile variations present in all the early B-Sgs. More details about this investigation can be found in Simón-Díaz et al. (2010), and in the talk contribution to these proceedings *"Macroturbulent broadening in Massive Stars and its possible connection to Stellar Oscillations"*.

2.3 Increasing the statistics of OB stars with reliable determined stellar & wind parameters

One of the main aims driving the compilation of the IACOB spectroscopic database is to perform a homogenous quantitative spectroscopic analysis of a statistically representative sample of high-resolution, high quality spectra of stars with spectral types ranging from O4 to B2. By means of these data we plan to refine the temperature calibration of Galactic O-type stars and to address important questions such as, e.g. the weak wind problem, the mass discrepancy, etc. The spectra will be analysed using the stellar atmopshere code FASTWIND (Puls et al. 2005), which allows us to create

large grids of reliable spherical, NLTE, line blanketed models with winds for O and B stars of all luminosity classes in reasonable computational time-scales. Two examples of results from preliminar analyses of the single lined objects from the IACOB database are presented in Figs 3 and 4. Recently, we have established a collaboration with the OWN group (P.Is R. Barbá & R. Gamen). They have been compiling for many years a similar database with southern O stars, also investigating the multiplicty nature of apparently single objects. We plan to join efforts to increase the sample of analyzed objects.
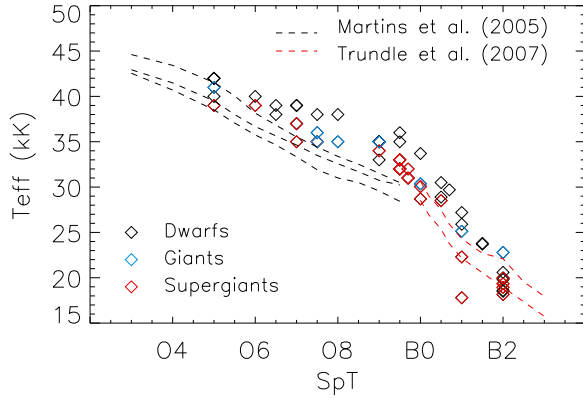

Figure 3: A homogeneous quantitative analysis of the IACOB spectra, accounting for binarity/multiplicity, will help to better define the SpT - T_{eff} calibrations in the O to early-B star domain. Results from the preliminary analyses with FASTWIND, and comparison with two published calibrations.
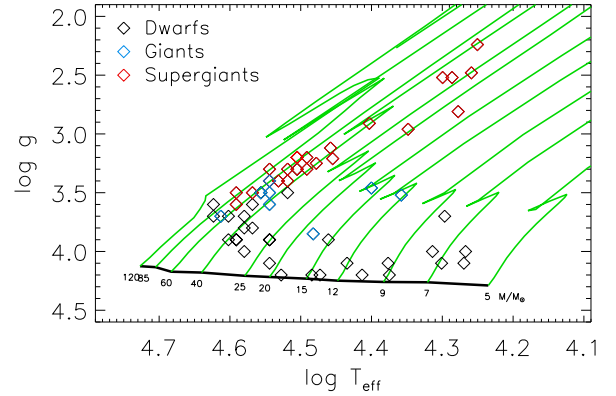
Figure 4: Position of the analyzed stars in the $(\log g, \log T_{eff})$ diagram, along with the ZAMS (black, solid line) and evolutionary tracks from Schaller et al. (1992) for stellar masses between 5 and 85 $M_{\odot}$ (green lines). Our analyses can help to better uncerstand the mass discrepancy problem.

A similar analysis is in progress within the *FLAMES-II Survey of Massive Stars: "The Tarantula survey"* consortium (P.I. C. Evans). Around 1000 OB stars in 30 Dor will be analyzed to derive their rotational velocities, stellar and wind parameters, and N abundances. The comparison of results from the two samples of stars (born in environments with different metalicity) will be of great importance for our undertanding of the physical properties and evolution of massive stars.

2.4 Homogeneity of O and Si abundances in B-type stars in Ori OB1

In Simón-Díaz (2010), we used FASTWIND to perform a self-consistent spectroscopic analysis of a sample of 13 early B-type stars from the Ori OB1 association observed with FIES@NOT. Main results of this study, as part of a series of papers grouped under the title *"The chemical composition of the Orion star forming region: stars, gas, and dust"* can be found in the poster contribution to these proceedings with the same title.

2.5 And more ...

- A subsample of spectra from the IACOB (along with UVES and FEROS spectra from the ESO archive) have been recently used within the *FLAMES-II Survey of Massive Stars: "The Tarantula survey"* consortium to create a template atlas for spectral classification of medium resolution spectra of early type stars (Sana, Simón-Díaz, Walborn et al., in prep.)

- Following ideas first presented in Markova et al. (2010), the IACOB database will be used (i) to investigate third parameter effects in the classification scheme developed by Walborn and

co-authors to type O-stars and (ii) to recalibrate the logarithmic EW rations underlaying the Conti classification scheme.

- We plan to use some of the IACOB spectra to analyze the feasibility of wavelet filtering to improve the signal-to-noise ratio and, based on the sparsity of the spectra in the wavelet domain, to envisione the possibility to do superresolution resting on the compressed sensing theory (Asensio Ramos & López Ariste, 2010).

3   Future of the IACOB

In the next semesters[2], we will continue with the compilation of spectra for the IACOB, observing stars with V≤8 in at least three epochs (more in the case of known or newly detected binaries). Our idea is to make public the database via the Virtual Observatory in the next year. In the meantime, interested people can have access to the database under request to the author (ssimon@iac.es). The complete list of stars will be published in Simón-Díaz et al., in prep.. We will acknowledge any observer who having obtained FIES spectra will like to add the spectra to the IACOB database after scientific exploitation.

Acknowledgements

References

Aerts, C., Puls, J., Godart, M., & Dupret, M.-A., 2009, A&A, 508, 409
Asensio Ramos & López Ariste, 2010, A&A, 509, 49
Barbá, R. H., Gamen, R., Arias, J. I., et al. 2010, RMAyA, 38, 30
Evans, C. J., Bastian, N., Beletsky, Y., et al., 2010, *IAU Symposium*, 266, 35
Evans, C. J., Hunter, I.; Smartt, S., al., 2008, *The Messenger*, 131, 25
Fraser, M., Dufton, P. L., Hunter, I., & Ryans, R. S. I., 2010, MNRAS, 404, 1306
Gray, D. F. 1976, *The Observations and Analysis of Stellar Photospheres* (1st ed.; New York: Wiley)
Markova, N., Puls, J., Scuderi, S., et al., A&A, submitted
Martins, F., Schaerer, D., & Hillier, D. J., 2005, A&A, 436, 1049
Maíz-Apellániz, J., Walborn, N. R., Galué, H. A.., & Wei, L. H., 2004, ApJS, 151, 103
Puls, J., Urbaneja, M. A., Venero, R., et al., 2005, A&A, 435, 669
Schaller, G., Schaerer, D., Meynet, G., & Maeder, A. 1992, A&AS, 96, 269
Simón-Díaz , 2010, A&A, 510, 22
Simón-Díaz & Herrero, 2007, A&A, 468, 1063
Simón-Díaz, S., Herrero, A., Uytterhoeven, K., et al., 2010, ApJL, 720, 174
Trundle, C., Dufton, P. L., Hunter, I., et al. 2007, A&A, 471, 625

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[2]The number of observed stars has already increased to ~ 140 between Sept. 2010 and the date of submission of this contribution